Long live the King River Perchlet (*Nannatherina balstoni*)

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Exactly 100 years following the discovery of Balston's Pygmy Perch (*Nannatherina balstoni*) and its subsequent description from south-western Australia, it was added to the Australian Government's endangered species list due to a contraction of the species range and its low abundance relative to sympatric species. The current study aimed to determine the historical and contemporary geographical range of the species, to quantify its range reduction and prioritise areas for ongoing monitoring and management. The original common name of this species, the King River Perchlet, was derived from the type locality of the two syntypes deposited at the British Museum of Natural History. Only one syntype remains. Based on a review of published information and unpublished data held by the authors, the apparent contemporary area of occurrence of *N. balstoni* is now ~69% of its historical distribution. The remaining syntype from the King River represents the only known specimen from that system and the species is no longer known to occur there. Similarly, the species appears to have been extirpated from the Moore River at the northern limit of its range during the latter part of the 20th century, and presumably also from many rivers of the Swan Coastal Plain as well as Turner Brook in the extreme south-western corner of its range. Based on genetic differences between populations, it is proposed that the loss of these populations is likely to have resulted in an irreversible loss of evolutionary significant units. A recovery plan is critical for the management of the species, with on-ground surveys required in order to confirm ongoing population viabilities. Quantification of the numerous threats to the species (e.g. impacts of instream barriers, surface flow and groundwater reductions due to climate change and water extraction, riparian degradation, secondary salinisation and the presence of introduced species) is also required.

KEYWORDS: Balston's Pygmy Perch, Percichthyidae, south-western Australia, salinisation, endangered species

INTRODUCTION

Nannatherina balstoni was described by C.T. Regan in 1906 (Regan 1906). Exactly 100 years later, it was added to the threatened species list of the Australian Government. It is one of four freshwater fish species of the Percichthyidae that is endemic to the Southwestern Province of Western Australia (Morgan *et al.* 2011), a region known as a globally significant hotspot of endemism (Myers *et al.* 2000; Olson & Dinerstein 2002).

The type locality of *N. balstoni* is the King River, just east of Albany, from which two specimens were collected by G.C. Shortridge and presented to the British Museum by W.E. Balston in 1906. Regan (1906) placed *N. balstoni* in the Atherinidae where it remained until 1940, when it was placed in the Kuhliidae (Regan 1940). Kuiter and Allen (1986) later placed it in the Percichthyidae before it was positioned in the Nannopercidae a few years later (Allen 1989; Kuiter *et al.* 1996). At the turn of this century, Jerry *et al.* (2001) demonstrated that the pygmy perches are monophyletic with *Macquaria*, resulting in the placement of *N. balstoni* back into the Percichthyidae.

Whitley (1947) first assigned the common name King River Perchlet in reference to the type locality of the species. Since then, alternative names have included Balston's Perchlet (Merrick & Schmida 1984) and Balston's Pygmy Perch (Allen 1982, 1989) after W.E. Balston, who presented the first specimens to the British Museum.

Historically, and prior to surveys in the early 1990s (see Morgan *et al.* 1998), little was known regarding the extent of the distribution of the species, with the exception of a few specimens housed in various museums (see Table 1). For example, Coy (1979) and Allen (1982, 1989) broadly list the species as having a distribution that is limited to the streams, lakes, ponds and swamps between Two Peoples Bay and the Blackwood River, although Webster (1949) had also discovered the species from north of the Blackwood River in the Margaret River near Rosa Brook in 1948 (Table 1). Knowledge of the distribution of *N. balstoni* increased markedly during the 1980s and 1990s and was documented by Morgan *et al.* (1998), who reviewed all historical collection data and also identified 35 additional occurrence localities between Margaret River and Two Peoples Bay (Goodga River). These records include rivers, coastal swamps and several lakes throughout the

Table 1 Specimens of *Nannatherina balstoni* that are housed in the collections of various institutions, including year of collection and collector. Abbreviations for institutions are as follows: Western Australian Museum (WAM), South Australian Museum (SAM), Museum Victoria (NMV), Australian Museum (AM), British Museum of Natural History (BMNH), South African Institute for Aquatic Biodiversity (SAIAB), and the National Museum of Natural History (AMNH). * Indicates type specimens. # Specimen may be from WAM.

Institution	Specimen ID	Year of collection (and collector)
BMNH	*BMNH 1906.11.1.21-22	1906 (Shortridge, G.C.)
AM	I.13265, I.13266	1914 (?)
WAM	P.3075.001	1947 (Shipway, B.)
WAM	P.4033.001	1957 (Butler, W.H.)
WAM	P.5761.001	1958 (Butler, W.H.)
WAM	P.5514.001	1962(Butler, W.H.)
NMV	A5520	1964 (Littlejohn, M.J.)
NMV	A514	1966 (Frankenberg, R.)
AMNH	315892	1969 (Rosen)
AMNH	315892.5	1969 (Rosen)
WAM	P.25697.003	1976 (Allen, G.R.)
WAM	P.27149.001	1981 (Pusey, B.)
WAM	P.27025.001	1981 (Przybylski)
WAM	P.28655.002	1986 (Allen, G.R. & Berra, T.)
WAM	P.28656.002	1986 (Allen, G.R. & Berra, T.)
WAM	P.28658.003	1986 (Allen, G.R. & Berra, T.)
WAM	P.28659.002	1986 (Allen, G.R. & Berra, T.)
SAIAB	55471	1986 (Berra, T. & Allen, G.R.)
WAM	P.28641.003	1986 (Berra, T. & Cross, N.)
WAM	P.28644.004	1986 (Allen, G.R. & Berra, T.)
WAM	P.28652.003	1986 (Allen, G.R. & Berra, T.)
AMNH	#USNM 289205	1986 (Allen, G.R.)
WAM	P.30438.004	1992 (Jaensch, R.)
WAM	P.30439.003	1992 (Jaensch, R.)
WAM	P.30443.002	1992 (Jaensch, R.)
WAM	P.30441.002	1992 (Jaensch, R.)
WAM	P.30450.002	1992 (Jaensch, R.)
WAM	P.30453.002	1992 (Jaensch, R.)
WAM	P.30444.002	1992 (Jaensch, R.)
WAM	P.30446.002	1992 (Jaensch, R.)
SAM	F13624	2008 (Adams, M.)
SAM	F13625	2008 (Adams, M.)
SAM	F13626	2008 (Adams, M.)
SAM	F13627	2008 (Adams, M.)
SAM	F13628	2008 (Adams, M.)
SAM	F13629	2008 (Adams, M.)
SAM	F13630	2008 (Adams, M.)

region and the Western Australian Museum has a collection of the species from an outlying locality in the Moore River catchment in the north of the Southwestern Province.

The most comprehensive ecological study of the species was that by Morgan *et al.* (1995), who described its habitats and biology, which included diet, reproductive development, spawning period and cues, longevity, and growth. Gill & Morgan (1998) described the larval development, including the pronounced ontogenetic shift in diet through larval stages to the juvenile stage, when the species begins to feed almost exclusively on fauna derived from terrestrial sources (e.g. insects). Beatty *et al.* (2011) examined the salinity tolerance of the species, in light of its highly restricted distribution in the Blackwood River, and found it to be far less tolerant than the widespread but sympatric *Nannoperca vittata* and *Galaxias occidentalis*. Within the Blackwood River catchment, the region's largest by discharge, the species is known to migrate in and out of a single perennial stream for breeding (Beatty *et al.* 2014). This stream, Milyeannup Brook, is a groundwater dependent ecosystem and is not affected by the secondary salinisation which has severely impacted large sections of the Blackwood River catchment (Morgan & Beatty 2003; Beatty *et al.* 2011).

Although the common name for this species has changed over time, contemporary literature favours the name Balston's Pygmy Perch (e.g. Morgan *et al.* 1995, 1998, 2011; Gill & Morgan 1998; Allen *et al.* 2002; Yearsley *et al.* 2006; Morgan 2009; Beatty *et al.* 2011, 2014). The original common name, King River Perchlet, is no longer appropriate for two reasons. Firstly, the species is much more widespread than first believed, and secondly, it is believed to have been extirpated from the King River.

In addition to the King River, it is likely that the species has been lost from the Moore River catchment, at the northern limit of its distributional range (Morgan *et al.* 1998, 2011; Morgan 2009), where it was collected in January 1981 (Western Australian Museum specimen number P.27025.001), as well as from Turner Brook, where it has not been collected since the 1960s (Morgan *et al.* 2013) (see Table 1). Thus, we know of three populations that have likely been extirpated since the species was first discovered, but it has also likely been lost from much of the Swan Coastal Plain between the historical population at Moore River and the existing Margaret River population. These findings are based on the species being common in near-coastal wetlands throughout its range, most of which are now dewatered throughout the Swan Coastal Plain (see Morgan *et al.* 2011) as well as the record of a single specimen captured in the Collie River by L. J. Pen in the 1980s (L. Pen, pers. com.).

The loss of populations, severe range fragmentation, and a typically low abundance (e.g. Morgan *et al.* 1995, 1998), resulted in *N. balstoni* being listed in 2006 as *Vulnerable* under the Australian Federal Government's *Environmental Protection and Biodiversity Conservation Act 1999*, with the species concurrently listed as *Schedule 1* under the Western Australia State Government's *Wildlife Conservation Act 1950*. However, its extent of occurrence and area of occupancy has not been quantified.

A major component of any threatened species recovery plan is current distributional information so that key habitats can be prioritised for conservation and management. Over the last quarter of a century, there has been additional distributional information gathered. Here we aimed to collate all existing records of the species to ascertain its current and historical extent of occurrence and identify key populations and habitats. We hypothesised that the geographical range of the species has continued to decline. It is our hope that this information will prove valuable in developing and implementing conservation efforts to maintain remnant populations of this listed threatened species.

DETERMINING THE HISTORICAL AND CONTEMPORARY DISTRIBUTION

The historical distribution of *N. balstoni* was determined via an extensive search of published scientific literature and museum databases (see Results). We also contacted various museums regarding specimens they held, or to clarify uncertainties in database searches, for example missing location data. Other unpublished data from our own surveys, which commenced in 1992, were included in the analyses. In some publications, the exact locality of the collection was not given (e.g. Pusey & Edward 1990; Morgan *et al.* 1995); however, they were incorporated into later publications (e.g. Morgan *et al.* 1998) and were also used in the present analyses. A species distribution map was created using ArcGIS™ Desktop 10, and sites were separated based on whether they were collected prior to, or after, the commencement of our distributional surveys in 1992.

Extent of occurrence

Previously known sites of capture of *N. balstoni* were used to estimate its extent of occurrence in ArcGIS™ Desktop 10. Extent of occurrence (EOO) was determined using the distributional point data by constructing minimum convex polygons (α-hulls) following IUCN guidelines (IUCN 2011).

Two α-hulls were constructed from the data. The first was constructed using all historical EOO point data excluding the outlying historical Moore River population. The second was constructed using all historic data and included an assumed additional area of occupation based upon historical and remnant distributions of sympatric species as discussed in Morgan *et al.* (1998). The areas of the resulting polygons were determined. The IUCN guideline stating that internal angles of the polygons should not exceed 180° was relaxed in order to exclude unsuitable habitat, i.e., the marine environment.

RESULTS

Specimens of *N. balstoni* were located in the collections of the Western Australian Museum, South Australian Museum, Museum Victoria, Australian Museum, British Museum of Natural History (Figure 1), South African Institute for Aquatic Biodiversity, and the National Museum of Natural History (Table 1). Published literature detailing collections of *N. balstoni* included: Christensen (1982) (four sites); Pusey & Edward (1990) (five sites); Morgan (1993) (11 sites); Morgan *et al.* (1995) (three sites, exact localities not given but taken from Morgan (1993)); Morgan *et al.* (1996) (29 sites); Morgan *et al.* (1998) (35 sites, 29 of which were identical to those in Morgan *et al.* (1996)); Morgan & Beatty (2003) (two sites); Morgan & Beatty (2005a) (one site); Morgan & Beatty (2005b) (four sites); Beatty *et al.* (2006) (four sites); Morgan *et al.* (2010) (two sites); Beatty *et al.* (2011) (one site) and; Beatty *et al.* (2014) (four sites) (Figure 2).

There have been no records of *N. balstoni* from the King River since the syntypes of the species were originally collected there in 1906 (Table 1). A recent survey of Turner Brook, in the extreme south-western corner of the State, failed to detect *N. balstoni*, which was previously collected from that system by W.H. Butler on several occasions between 1957 and 1962 (Table 1, Figure 1) (Morgan *et al.* 2013). Similarly, there are no records of *N. balstoni* from the Moore River catchment since they were first collected there in 1981 by G.R. Allen.

Table 2 Assumed current (i.e. using historical species presence data excluding the extirpated Moore River population) and estimated historical (i.e. using historical species presence data with additional area of assumed past distribution) area of occurrence of *Nannatherina balstoni* in south-western Australia.

Point data description	Area of occurrence (sq. km)	Perimeter of occurrence (km)
Assumed current distribution	15867	726
Estimated historical distribution	22859	1366

The contemporary distribution of *N. balstoni* is approximately 69% of its historical area of occupancy (Table 2, Figure 2). The abundance of *N. balstoni* relative to sympatric species is typically low, but no studies have been published specifically to estimate population sizes. Studies that provide some indication of population size are restricted to those by Beatty *et al.* (2014) and to a lesser extent Morgan *et al.* (1995). However, the authors are conducting a study to quantify the abundance of sympatric percichthyids (i.e. Balston's Pygmy Perch, Western Pygmy Perch *Nannoperca vittata*, Little Pygmy Perch *Nannoperca pygmaea*, and Nightfish *Bostockia porosa*) in refuge pools in the Hay River, with preliminary results revealing that the abundance of the Balston's Pygmy Perch was only 0.3% of the total number of pygmy perches present. Aside from Milyeannup Brook (Beatty *et al.* 2014), this low level of abundance of the species appears typical throughout its range.

DISCUSSION

Based on the records collated here, the approximate 31% reduction in range of *N. balstoni* appears to have occurred during the last quarter of the 20th century. This reduction is due to the loss of the northernmost population in the Moore River, the loss of the Turner Brook population, and from the likely loss of populations along the Swan Coastal Plain. Further range contractions are suspected to have occurred due to human-induced secondary salinisation in many of the region's larger river systems that house this species such as the Blackwood River (e.g. Beatty *et al.* 2011, 2014). It is paramount that historical sites are re-surveyed, including those where limited data exist, those where capture methods were used that are less effective than current methods (i.e. fyke netting: with the first reported use of this method to target south-western Australian freshwater fish being from 2004 in the Blackwood River (Morgan & Beatty 2005b), as well as those that were once known to support robust populations (e.g. Morgan *et al.* 1995, 1998; Beatty *et al.* 2014).

Based on allozyme evidence, Murphy *et al.* (2010) found three distinct genetic lineages for *N. balstoni*, one

Figure 1 (Above) The remaining syntype of *Nannatherina balstoni* from the King River (BMNH1906.11.1.21-21) (image provided by James Maclaine, British Museum of Natural History). (Below) Two specimens (WAM P.5761.001) of *N. balstoni* from Turner Brook collected in 1958 by W.H. Butler (photograph G. Moore).

in the upper Margaret River, one in the Gardner and Shannon rivers, and one that included fish from the Blackwood, Deep, Hay and Angove rivers. Using mtDNA, Murphy *et al.* (2010) demonstrated that, genetically, almost all populations of *N. balstoni* were significantly different to each other. Therefore, the loss of the Moore River, King River and Turner Brook populations has likely resulted in the irreversible loss of at least three genetically unique populations (see Figure 1). It is recommended that long term monitoring of populations across the range of the species is included in any recovery plan.

The mechanism for loss of *N. balstoni* from its type locality (King River) is unknown, but may be related to the presence of introduced species such as *Gambusia holbrooki* and/or *Oncorhynchus mykiss*, the latter of which was, until very recently, annually stocked into the river.

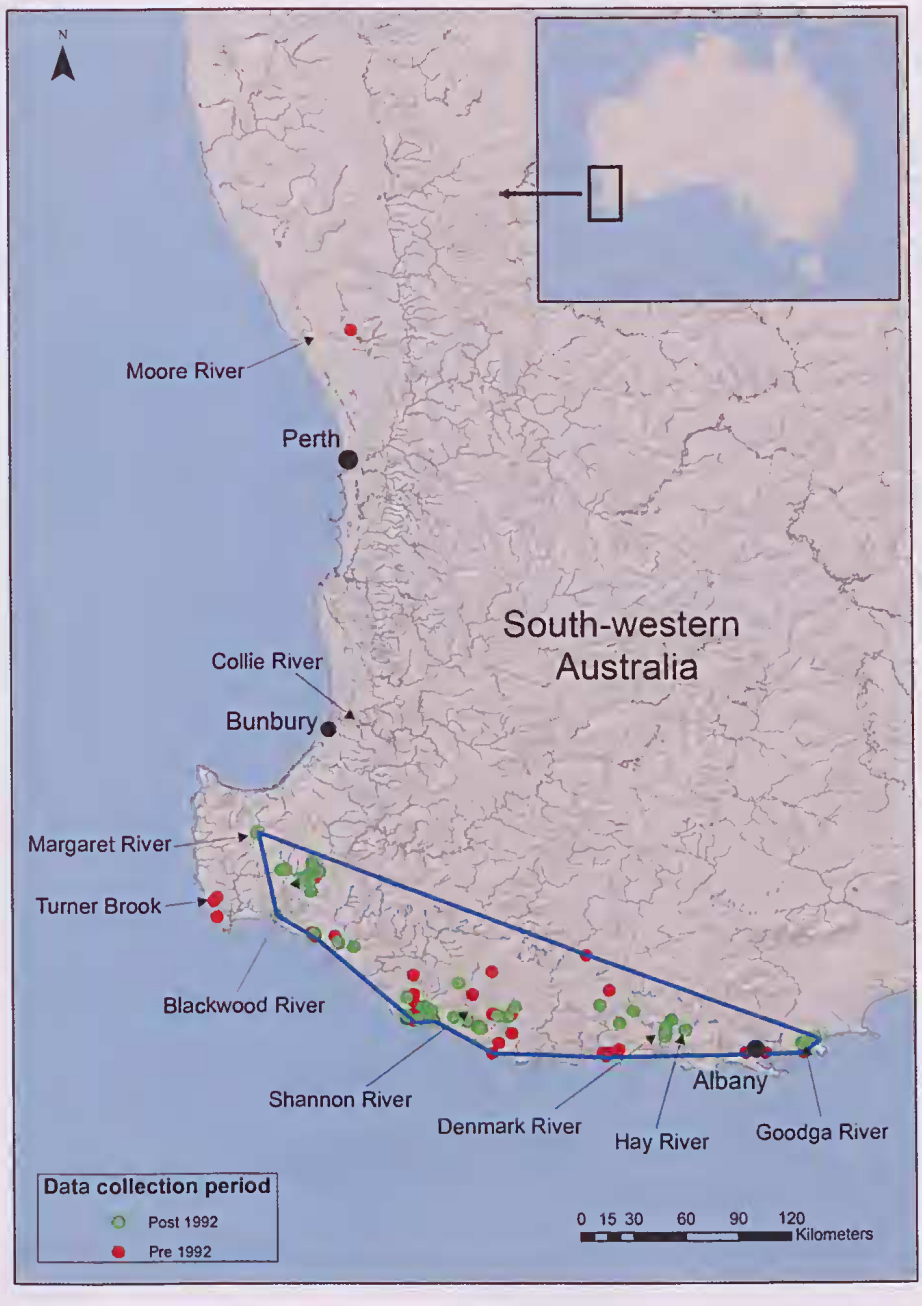

Figure 2 The known location points of *Nannatherina balstoni*. The current area of occupancy of *N. balstoni* is based on the distribution locations excluding the presumed extirpated populations in the Moore River and Turner Brook. These data are based on collections by the authors since 1992 and those deposited in various museums prior to 1992.

The only known *N. balstoni* specimens from the river are the two syntypes, one of which appears to have been lost. The second specimen is thus the sole remaining primary type specimen for the species (Figure 1) (BMNH1906.11.1.21-21).

Ground truthing data from the historical sites identified in the current study (Figure 1) is required in order to update the extant distribution and determine recent population trends. Such data will help guide management strategies for this species by identifying other populations that may have been lost and those populations that remain viable, as well as helping to formulate hypotheses surrounding the causes of the decline of *N. balstoni*. Any future recovery plans for the species should identify sites at risk from anthropogenic stressors and important refuge habitats. Such sites should be based on the re-examination of historically known populations and from the identification of populations that represent the most genetically significant units.

Management strategies, such as the designation of fish habitat protection areas (FHPA), public education including riparian landholders, and the quantification and mitigation of likely impacts on the species such as instream barriers, riparian zone degradation, and introduced fish species, are urgently required to abate the decline of this threatened, endemic species.

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